Cross Compilation and GCC

GCC Version 4.0.2

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Short Contents

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1 Introduction

In a chapter devoted to a description of the practical aspects of writing a compiler, Aho, Ullman and Sethi⟨undefined⟩ [aho-sethi-ullman], page ⟨undefined⟩ use a T diagram proposed by Bratman⟨undefined⟩ [bratman], page ⟨undefined⟩. The T diagram is used to concisely represent the three main components of compiler writing: S – the source language accepted by the compiler, T – the target language to which programs in S are compiled to, and I – the implementation language used to write the compiler itself. The notation is effectively used to discuss compiler development including bootstrapping. In this notice we present a variation of the notation and employ it to describe the construction of a cross tool chain. The symbolic nature of the notation clearly brings out the consistency of the chaining requirements. This is demonstrated by employing the notation to describe the generation of a native tool chain for a new target using the generated cross tool chain.

2 Generalizing the Notation

The T diagram captures a translation from source language S to a target language T. The implementation language, I, is also the language whose interpreter can execute the compiler. We will refer to I as the interpretation, i.e. the execution, language. This permits us to concisely express a translator L that executes on I and translates from a source language S to a target language T as $^SL^T_I$. The symbols S, T and I occupy the same positions as in the T diagram. However, the ordinarily empty T diagram now has the name of the translator L at it's center and the rest of the T diagram is discarded. The name of the translator is used to denote the individual components of a conventional tool chain. To use the notation, we substitute S, T and I appropriately.

3 The Tool Chain

The conventional tool chain, T, that generates an executable from a set of source language files is made up of a compiler C, an assembler A, and a linker L. The linker also uses any necessary library LIB along with the input received from the previous components of the tool chain. Denote high level language used to express a program by c, the corresponding assembly program by s, the object language program by o and the final executable language by x.

Ignoring the library for a moment, the native tool chain is \beginequation ^cT^x_x : ^cC^s_x \rightarrow ^sA^o_x \rightarrow ^oL^x_x \endequation where the → is an infix sequencing operator that sequences the operation on the RHS after the operation on it's LHS.

The library is not truly a translation system. It is a repository of object files and serves the linker to complete its job. To include it we cannot use the sequence operation. Instead, we introduce a higher precedence "parallel" operation, denoted by an infix '||', that expresses the subsidiary, but necessary, role of the library to the linker. Because the library is not a translation system, it need not strictly follow our variant of the T diagram. In fact, it just undergoes a translation as any other program would when passed through the tools. We denote the library by LIB and the "execution" language that it is in is denoted by a right subscript so that overall notational consistency is preserved when expressing the operation of the translation tools on it. Thus, the library source code in source language c is denoted by LIB_c. When the library has been compiled it is in assembly language and is then denoted as LIB_s. Finally after being assembled the library is denoted as LIB_o. Including the library into Eq.([eq:basic:tool:chain:schematic], page 3), the tool chain is \beginequation ^cT^x_x : ^cC^s_x \rightarrow ^sA^o_x \rightarrow LIB_o \vert\vert ^oL^x_x \endequation

4 The Cross Tool Chain Problem

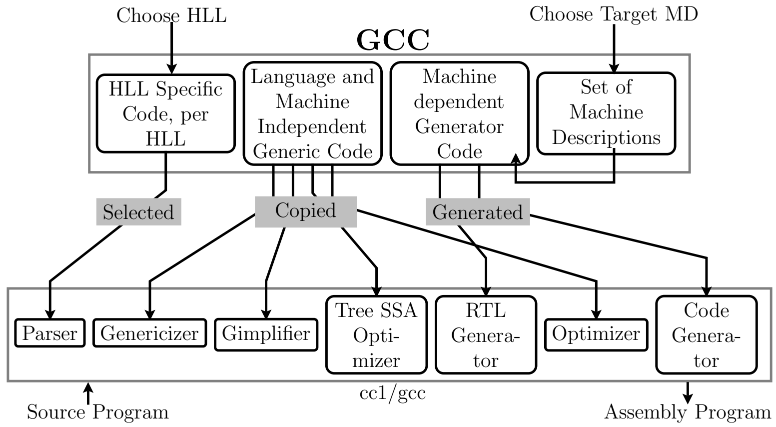

Figure 4.1: The cross compilation problem and notation.

A cross tool chain generates executables for a different target than the one on which it itself runs. Denote the cross target by a primed right superscript. The cross tool chain problem can be stated as:

Given the tool chain on the host, Eq.([eq:basic:tool:chain], page 3), and the sources, \begineqnarray ^cC^s_c &~& \mathrm The\ Compiler\ Source\ Code \\ ^sA^o_c &~& \mathrm The\ Assembler\ Source\ Code \\ ^oL^x_c &~& \mathrm The\ Linker\ Source\ Code \\ LIB_c &~& \mathrm The\ Library\ Source\ Code \endeqnarray we need to generate \beginequation ^cT^x^\prime_x : ^cC^s^\prime_x \rightarrow ^s^\primeA^o^\prime_x \rightarrow LIB_o^\prime \vert\vert ^o^\primeL^x^\prime_x. \endequation

The compiler $^cC^s_c$ in Eq.([eq:basic:cross:tool:chain], page 4) is complete in the sense that it has information about the signatures of the names provided by the library LIB. Without this information, the compiler would not be able to perform certain checks on a few objects that may appear in the source code. The tool chain would fail in it's final phase when the linker resolves references to any library objects referred to in the original input source. If the source did not refer to any objects in the library, then the basic tool chain in Eq.([eq:basic:tool:chain], page 3) would work. Fig.(Figure 4.1) states the problem and details the notation used.

5 Cross Compiler Generation

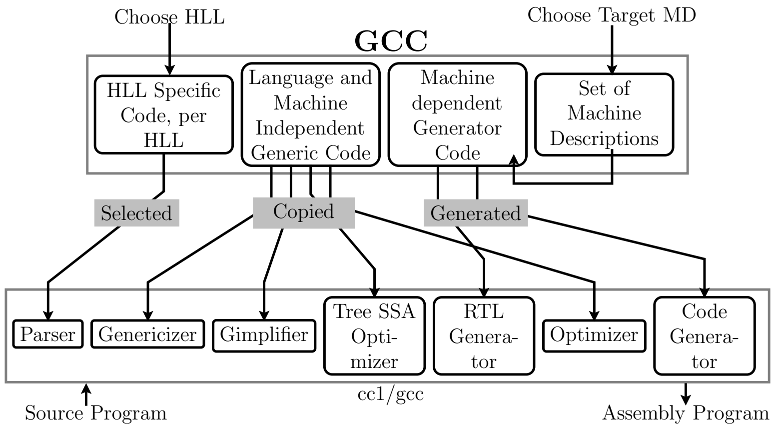

Figure 5.1: Steps in generating the cross compiler hosted on the unprimed system.

Given the compiler sources (primed to denote a cross target), Eq.([eq:given:comp], page 4), we use the tools chain on the host, Eq.([eq:basic:tool:chain], page 3) to generate the cross compiler. \beginequation ^\mbox$^cC^s^\prime_c$ \rhd\ _\mbox$^cT^x_x$\ \rhd\ ^\mbox$^cC^s^\prime_x$, \endequation where the translation tool has been subscripted relative to the flow operation, $\rhd$, to clearly denote the translation of the execution language of the input to the execution language of the output. The flow operation expresses the input and output behaviour of the translation tool and distributes over the sequence operation. Note that the sequence operator denotes the temporal order of occurrence of the objects in the sequence. Thus, the sources must occur before the translation is invoked. Similarly, from Eq.([eq:given:asm], page 4) we generate the cross assembler \beginequation ^\mbox$^s^\primeA^o^\prime_c$ \rightarrow\ _\mbox$^cT^x_x$\ \rightarrow\ ^\mbox$^s^\primeA^o^\prime_x$, \endequation and the cross linker from Eq.([eq:given:link], page 4) \beginequation ^\mbox$^o^\primeL^x^\prime_c$ \rightarrow\ _\mbox$^cT^x_x$\ \rightarrow\ ^\mbox$^o^\primeL^x^\prime_x$. \endequation Eqs.([eq:cross:compiler:one], page 5–[eq:cross:linker:one], page 5) yield an incomplete cross tool chain, $^cT^x^\prime_x$: \beginequation ^cT^x^\prime_x : ^cC^s^\prime_x \rightarrow ^s^\primeA^o^\prime_x \rightarrow ^o^\primeL^x^\prime_x \endequation

Eq.([eq:cross:tool:chain:one], page 5) can generate executables of source programs that do not involve calls to library names. In particular, it's components can be used to obtain the cross library from the sources, Eq.([eq:given:lib], page 4), as follows: \beginequation ^\mbox$LIB_c$ \rightarrow\ _\mbox$^cC^s^\prime_x$\ \rightarrow\ ^\mbox$LIB_s^\prime$ \rightarrow\ _\mbox$^s^\primeA^o^\prime_x$\ \rightarrow\ ^\mbox$LIB_o^\prime$. \endequation

The process is summarized in Fig.(Figure 5.1). The first stage is depicted in box 1. In this stage the tool chain is incomplete in that the information about the signatures of the symbols provided by the library LIB are not available. However the tool chain components are otherwise capable of generating the desired outputs. Hence they can be used in box

2 where the library for the target is generated. The library is successfully built when the object files are created. At this point the cross target specific information about the library, LIB_info, is available and can be used in the final cross build sequence depicted in box 3 in the figure. The tool chain components generated in box 3 are now complete. This is an example of the bootstrap process applied to the tool chain problem that is used to build the complete compiler as a part of the final target cross tool chain. Note that each component of the tool chain is hosted on the unprimed system but generates output for the primed system. The result of the sequence in box 3 is the generation of a complete cross tool chain.

6 Generation of a Native Tool Chain for a New Target

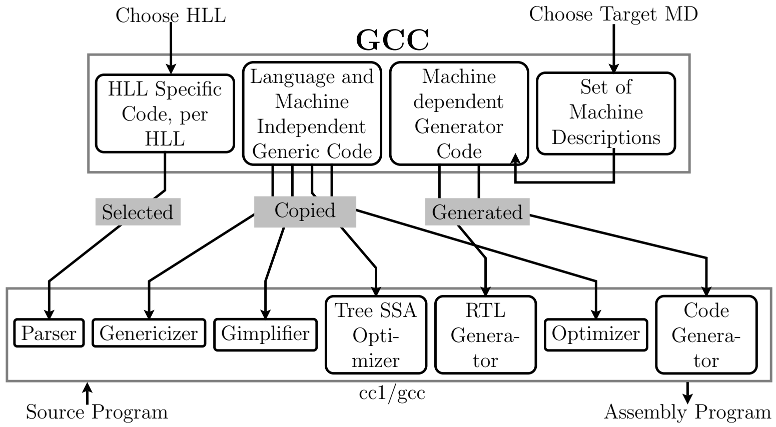

Figure 6.1: primed target.

Generating a complete native tool chain for the new, primed target. ,

The cross tool chain $^cT^x^\prime_x$ can be used to generate a fully native tool chain, $^cT^x^\prime_x^\prime$, for the primed target. This is done by using the cross tool chain $^cT^x^\prime_x$ on the sources $^cC^s^\prime_C$, $^s^\primeA^o^\prime_C$, and $^o^\primeL^x^\prime_C$. The process is shown in Fig.(Figure 6.1). Note that the library need not be generated again since it has already been generated while generating the cross tool chain except for minor issue like re-encoding any new installation location.

The process can be repeated to achieve a canadian cross build. This is possible since we have started from a native tool chain for the host and finally built a native tool chain for the new target. This native tool chain on the new target can be used to generate a complete cross tool chain for the target of the canadian cross.

7 Conclusion

We have used a variant of the T diagram, and introduced two operators, the sequencing operator $\rightarrow$ and the parallel operator $||$, to concisely capture the process of building a tool chain. A tool chain is not just a sequence of translation tools. It also uses information from other source, the library. Hence we have introduced the “parallel” operator. The building of the cross tool chain is continued further to generate a native tool chain for a new target and the generation circle is completed. As a consequence the process of canadian crosses is just an extension. While these issues are known in practice, a clear description of the process has been possible using the variant of the T diagram notation.

References

List of Figures

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